

AMENDMENTS TO THE CLAIMS

1 1. (Currently amended) An estimation method for estimating illumination on
2 a sensor capable of capturing non-destructively a plurality of image samples during an
3 exposure period, said method comprising the steps of:

4 measuring an illumination indication from said sensor, said measuring occurs a
5 multiplicity of two or more times at intervals during said exposure period, ~~thereby~~
6 producing a multiplicity of measurements; and

7 determining, based on an optimal weighted averaging process, an estimated
8 illumination on said sensor from said multiplicity of measurements.

1 2. (Original) The estimation method of claim 1, wherein said sensor is a
2 photodiode and said illumination indication is a charge accumulated from photocurrent
3 produced by said photodiode.

1 3. (Original) The estimation method of claim 2, wherein said measuring step
2 occurring non-destructively and said charge accumulating over said exposure period.

1 4. (Original) The estimation method of claim 1, wherein said determining
2 step including statistical signal processing of said multiplicity of measurements, said
3 signal processing being based on a noise model selected from a fixed pattern noise
4 model, a reset noise model, a shot noise model and a read noise model.

1 5. (Original) The estimation method of claim 1, wherein said determining
2 step including statistical signal processing of said multiplicity of measurements, said
3 signal processing being based on maximizing a likelihood of accuracy of said estimated
4 illumination.

1 6. (Original) The estimation method of claim 1, wherein said determining
2 step including statistical signal processing of said multiplicity of measurements, said
3 signal processing being based on minimizing an error of said estimated illumination.

1 7. (Original) The estimation method of claim 1, wherein said determining
2 step including statistical signal processing of said multiplicity of measurements, said
3 signal processing being based on minimizing a linear mean square error of said estimated
4 illumination.

1 8. (Original) The estimation method of claim 1, wherein said sensor is
2 configured in a sensor array, a pixel sensor in a digital camera, a pixel sensor in a video
3 camera, a pixel sensor in a stereo digital camera or a pixel sensor in a stereo video
4 camera.

1 9. (Currently amended) An estimation method for non-recursively estimating
2 an optimal illumination on a sensor capable of capturing non-destructively a plurality of
3 image samples during an exposure period, said method comprising the steps of:

4 measuring an illumination indication from said sensor;

5 storing said illumination indication, wherein said measuring and storing steps
6 occur ~~a multiplicity of two or more~~ times during said exposure period, ~~thereby~~
7 collecting non-destructively a multiplicity of measurements; and

8 performing a non-recursive optimal illumination estimation on said sensor from
9 all or essentially all of said collected multiplicity of measurements.

1 36. (Previously presented) The estimation method of claim 9, wherein said
2 determining step comprising statistical signal processing of said multiplicity of
3 measurements, said signal processing being based on a noise model selected from a fixed
4 pattern noise model, a reset noise model, a shot noise model and a read noise model.

1 10. (Original) The estimation method of claim 9, wherein said sensor is a
2 photodiode and said illumination indication is a charge accumulated from photocurrent
3 produced by said photodiode.

1 11. (Original) The estimation method of claim 10, wherein said measuring
2 step occurring non-destructively and said charge accumulating over said exposure period.

3 12. (Original) The estimation method of claim 9, wherein said determining
4 step including statistical signal processing of said multiplicity of measurements, said
5 signal processing being based on maximizing a likelihood of accuracy of said estimated
6 illumination.

1 13. (Original) The estimation method of claim 9, wherein said determining
2 step further comprising statistical signal processing of said multiplicity of measurements,
3 said signal processing being based on minimizing an error of said estimated illumination.

1 14. (Original) The estimation method of claim 9, wherein said determining
2 step further comprising statistical signal processing of said multiplicity of measurements,
3 said signal processing being based on minimizing a linear mean square error of said
4 estimated illumination.

1 15. (Original) The estimation method of claim 9, wherein said sensor is
2 configured in a sensor array, a pixel sensor in a digital camera, a pixel sensor in a video
3 camera, a pixel sensor in a stereo digital camera or a pixel sensor in a stereo video
4 camera.

1 16. (Currently amended) An estimation method for recursively estimating an
2 optimal illumination on a sensor capable of capturing non-destructively a plurality of
3 image samples during an exposure period, said method comprising the steps of:
4 measuring an illumination indication from said sensor, said measuring occurs a
5 multiplicity of two or more times at intervals during said exposure period, ~~thereby~~
6 producing a multiplicity of measurements; and

7 determining an estimated illumination on said sensor from all or essentially all of
8 said multiplicity of measurements non-destructively captured before motion/saturation,
9 said determining step occurring recursively over said multiplicity of measurements and
10 including statistical signal processing of said multiplicity of measurements, said signal
11 processing being based on a noise model selected from a fixed pattern noise model, a
12 reset noise model, a shot noise model and a read noise model.

1 17. (Currently amended) The estimation method of claim 16 further
2 comprising a step of maintaining a plurality of parameters during said measuring step,
3 said plurality of parameters comprising:
4 said estimated illumination;
5 means for ~~weighting~~ weighing a particular one of said multiplicity of
6 measurements;
7 means for indicating variance between said particular one of said multiplicity of
8 measurements and said multiplicity of measurements; and
9 means for indicating overall variance of said multiplicity of measurements.

1 18. (Original) The estimation method of claim 16 further comprising a step of
2 maintaining a plurality of parameters during said measuring step, said plurality of
3 parameters comprising:
4 said estimated illumination;
5 a weighting coefficient applied to a difference between a present one of said
6 multiplicity of measurements and said estimated illumination corresponding to a previous
7 one of said multiplicity of measurements;
8 a mean square error of said estimated illumination; and
9 a covariance of said estimated illumination with said present one of said
10 multiplicity of measurements.

1 19. (Original) The estimation method of claim 16, wherein said sensor is a
2 photodiode and said illumination indication is a charge accumulated from photocurrent
3 produced by said photodiode.

1 20. (Original) The estimation method of claim 16, wherein said measuring
2 step occurring non-destructively and said charge accumulating over said exposure period.

3 21. (Original) The estimation method of claim 16, wherein said determining
4 step including statistical signal processing of said multiplicity of measurements, said
5 signal processing being based on maximizing a likelihood of accuracy of said estimated
6 illumination.

1 22. (Original) The estimation method of claim 16, wherein said determining
2 step further comprising statistical signal processing of said multiplicity of measurements,
3 said signal processing being based on minimizing an error of said estimated illumination.

1 23. (Original) The estimation method of claim 16, wherein said determining
2 step further comprising statistical signal processing of said multiplicity of measurements,
3 said signal processing being based on minimizing a linear mean square error of said
4 estimated illumination.

1 24. (Original) The estimation method of claim 16, wherein said sensor is
2 configured in a sensor array, a pixel sensor in a digital camera, a pixel sensor in a video
3 camera, a pixel sensor in a stereo digital camera or a pixel sensor in a stereo video
4 camera.

1 25. (Currently amended) An apparatus configured to estimate illumination on
2 a sensor during an exposure period, said apparatus comprising:

3 a sampling means configured to measure an illumination indication, at a
4 ~~multiplicity of two or more~~ time intervals during said exposure period, ~~an illumination~~
5 ~~indication from a sensor~~, and ~~configured to thereby~~ produce a multiplicity of
6 measurements thereof;
7 a linear mean square estimation means configured to derive optimal weights from
8 said multiplicity of measurements; and
9 an estimation means configured to determine, based on weighted averaging
10 utilizing said optimal weights, an estimated illumination on said sensor from said
11 multiplicity of measurements.

1 26. (Original) The apparatus of claim 25, wherein said sensor is implemented
2 in a sensor array, a pixel sensor in a single chip imaging device, a pixel sensor in a digital
3 camera, a pixel sensor in a video camera, a pixel sensor in a stereo digital camera or a
4 pixel sensor in a stereo video camera.

1 27. (Original) The apparatus of claim 25, wherein said sensor is a photodiode
2 and said illumination indication is a charge accumulated from photocurrent produced by
3 said photodiode.

1 28. (Original) The apparatus of claim 27, wherein said sampling means
2 operates non-destructively and said charge accumulates over said exposure period.

1 29. (Original) The apparatus of claim 25, wherein said estimation means being
2 configured to perform statistical signal processing of said multiplicity of measurements,
3 said signal processing being based on a noise model selected from a fixed pattern noise
4 model, a reset noise model, a shot noise model and a read noise model.

1 30. (Original) The apparatus of claim 25, wherein said estimation means being
2 configured to perform statistical signal processing of said multiplicity of measurements,

3 said signal processing being based on maximizing a likelihood of accuracy of said
4 estimated illumination.

1 31. (Original) The apparatus of claim 25, wherein said estimation means being
2 configured to perform statistical signal processing of said multiplicity of measurements,
3 said signal processing being based on minimizing an error of said estimated illumination.

1 32. (Original) The apparatus of claim 25, wherein said estimation means being
2 configured to perform statistical signal processing of said multiplicity of measurements,
3 said signal processing being based on minimizing a linear mean square error of said
4 estimated illumination.

1 33. (Currently amended) An apparatus configured to estimate illumination on
2 a sensor during an exposure period, said apparatus comprising:

3 a sampling means configured to measure, at a multiplicity of time intervals during
4 said exposure period, an illumination indication from ~~a~~said sensor, and configured to
5 ~~thereby~~ produce a multiplicity of measurements; and

6 an estimation means configured to determine an estimated illumination on said
7 sensor from said multiplicity of measurements, said estimation means being configured to
8 compute recursively over said multiplicity of measurements and to maintain recursively a
9 plurality of parameters over said multiplicity of measurements, said plurality of
10 parameters comprising:

11 said estimated illumination;

12 means for ~~weighting~~weighing a particular one of said multiplicity of
13 measurements;

14 means for indicating variance between said particular one of said multiplicity of
15 measurements and said multiplicity of measurements; and

16 means for indicating overall variance of said multiplicity of measurements.

1 34. (Currently amended) An apparatus configured to estimate illumination on
2 a sensor during an exposure period, said apparatus comprising:
3 a sampling means configured to measure, at a multiplicity of time intervals during
4 said exposure period, an illumination indication from ~~a~~ said sensor, and configured to
5 ~~thereby~~ produce a multiplicity of measurements; and
6 an estimation means configured to determine an estimated illumination on said
7 sensor from said multiplicity of measurements, wherein said estimation means being
8 configured to perform statistical signal processing of said multiplicity of measurements,
9 said signal processing being based on a noise model selected from a fixed pattern noise
10 model, a reset noise model, a shot noise model and a read noise model, and wherein said
11 estimation means being configured to compute recursively over said multiplicity of
12 measurements and to maintain recursively a plurality of parameters over said multiplicity
13 of measurements, said plurality of parameters comprising:
14 said estimated illumination;
15 a weighting coefficient applied to a difference between a present one of said
16 multiplicity of measurements and said estimated illumination corresponding to a previous
17 one of said multiplicity of measurements;
18 a mean square error of said estimated illumination; and
19 a covariance of said estimated illumination with said present one of said
20 multiplicity of measurements.

1 35. (Currently amended) An apparatus configured to estimate illumination on
2 a sensor during an exposure period for simultaneously reducing noise and improving
3 dynamic range at low illumination end, where said sensor is configured in a
4 complementary metal oxide semiconductor (CMOS) image sensor system capable of
5 capturing multiple image samples during said exposure period, said apparatus
6 comprising:

7 means for measuring, at ~~a multiplicity of~~ two or more intervals during said
8 exposure period, actual photocurrent from said sensor, said means for measuring ~~thereby~~
9 producing a multiplicity of photocurrent measurements; and

10 means for estimating optimal photocurrent on said sensor from said multiplicity
11 of measurements, utilizing all or essentially all photocurrent measurements non-
12 destructively captured before motion/saturation.